Informational Leaflet 132

FORECAST OF THE SOCKEYE SALMON RUN TO CHIGNIK IN 1969

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DEPARTMENT OF
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IMPORTANT NOTE

The forecast contained herein was prepared jointly by indicated authors of two agencies: Fisheries Research Institute, University of Washington and the Alaska Department of Fish and Game. The discussion of escapement goals and resultant estimated commercial harvests on pages 3 and 5 of this leaflet are, however, the sole responsibility of the management agency, the Department of Fish and Game.

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BACKGROUND

Annual forecasts of the magnitude of the run of sockeye salmon to the Chignik River system were begun by the Fisheries Research Institute in 1958. The Alaska Department of Fish and Game has assisted in the collection and evaluation of data since 1960. Dalhberg (1968) analyzed the catch, escapement, and age records of the Chignik sockeye runs since 1888, modified the system of forecasting the magnitude and timing of the Black Lake stock, and developed a new method of forecasting for the Chignik Lake stock.

The present forecast of the Chignik sockeye run is a result of cooperative effort of biologists of the Fisheries Research Institute and the Alaska Department of Fish and Game. Project responsibilities in 1968 were as follows:

For the Fisheries Research Institute - Mr. William Parr was responsible for the Chignik program, conducted nursery lake studies, and read the scale samples used in the age analysis of the 1968 run.

For the Alaska Department of Fish and Game - Mr. Paul Pedersen was responsible for the collection of catch and escapement statistics and supervised the collection of information for determination of age and size composition of the runs. Mr. Pedersen and Mr. Parr conducted tagging studies, the results of which were used as a basis for determining the time of entry of the two stocks of Chignik sockeye.

FORECAST METHODS

Since 1964 the forecasts of the early and late segments of the Chignik run (essentially the Black Lake and Chignik Lake stocks) have been derived separately. Dahlberg (1968) presents the methods of forecasting both stocks. A general description of the techniques and the mathematical equations are presented in the appendix.

Black Lake

The forecast of the abundance of age .3[1] Black Lake fish is based on the number of spawners in the parent year and the number of age .2 fish one year before the return of age .3 fish (Appendix: forecast methods). Since most Black Lake fish are 1.3 at maturity, the escapement five years before the return of the age .3 fish is used for an estimate of the abundance of parent spawners. The number of age .2 fish in the run of the previous five years. The expected number of Black Lake fish is the sum of the estimated numbers of .2 and .3 fish.

Chignik Lake

Until 1967, the number of age .3 fish bound for Chignik Lake was estimated by averaging the runs in recent years. The forecasts were not accurate, and Dahlberg (1968) investigated several new methods of forecasting to find a reliable one. The best method found is based on the relationship between the ratio of abundance of age .3 fish in one year to that of age .2 fish in the previous year and the abundance of age .2 fish in the previous year (the ratio of abundance of age .3 to that of age .2 fish changes with the abundance of age .2 fish). The regression model used for this relationship is given in the Appendix.

Since we know the number of age .2 fish returning in a given year, we can estimate the ratio of age .3 fish to age .2 fish and then the number of age .3 fish in the run in the following year. Again, as with Black Lake, the number of age .2 fish that will return can be best estimated by the average number that returned in the five previous years.

FORECAST OF THE RUN IN 1969

Abundance

The expected magnitude and age composition of the Black Lake stock in 1969 are as follows:

Age .3 fish = 319,000

Age .2 fish = 38,000

Total stock = 357,000

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[1]The age designations .2 and .3 refer to fish which have spent 2 and 3 winters in the ocean, respectively. The designation 1.3 indicates that the fish spent one winter in freshwater after emergence from the gravel and three winters in the ocean. The period is used to separate the numerals for freshwater and the ocean "age."

The expected magnitude and age composition of the Chignik Lake stock in 1969 is as follows:

Age .3 fish = 608,000

Age .2 fish = 55,000

Total stock - 663,000

Time of Entry

In order to make best use of the forecast the management agency and the fishing industry need to know when to expect the run to enter the fishery. This knowledge is helpful to the fishing industry in planning its operation. It enables the management agency to regulate more precisely the fishery so that each lake receives its target escapement.

Since the time of entry pattern and duration of the run varied little between years in the period 1962-1968 the average time of entry curves for each stock were used to predict the time of entry for the run in 1969 (Fig. 1).

DISCUSSION

The predicted total return of 1,020,000 sockeye to the Chignik River system in 1969 compares favorably with the past 10-year average of 981,000 fish. However, the Black Lake forecast of 357,000 sockeye is slightly below the 10-year average of 411,000, probably as a result of the relatively small number (137,073) of parent spawners in 1964.

The optimum escapement for the Black Lake system has been estimated (Narver, 1966; Dahlberg, 1968) to be in the range of 400,000 sockeye. In view of the forecast of only 357,000 fish for Black Lake, and if the return is in the range predicted, commercial fishing prior to July 1 will be significantly restricted to allow adequate escapement to the Black Lake spawning grounds. Since some Black Lake fish are still passing through the commercial fishery after July 1 and since it will then be necessary to allow commercial fishing on the Chignik Lake stocks in order to assure adequate harvest of this stronger return, at least a small portion of the Black Lake return will be harvested incidentally with the Chignik Lake return. If the Black Lake return should be stronger than forecasted, an attempt will be made to obtain an escapement nearer the estimated optimum escapement of 400,000.

The optimum escapement for the Chignik Lake system has been estimated (Narver, 1966; Dahlberg, 1968) to be in the range of 200,000 sockeye until the Black Lake system has been stabilized. If the optimum escapement for Black Lake is not achieved in a given year, then the Chignik Lake escapement should be increased to about 250,000. (Studies have indicated that if Black Lake receives escapements in excess of optimum escapement, a portion of the resulting sockeye fry produced may migrate from the Black Lake rearing areas to the Chignik Lake rearing areas. If this phenomena occurs, overutilization of the Chignik Lake rearing areas could occur, thereby resulting in additional fry mortalities.) The 1969 forecast of 663,000 fish to the Chignik Lake system,

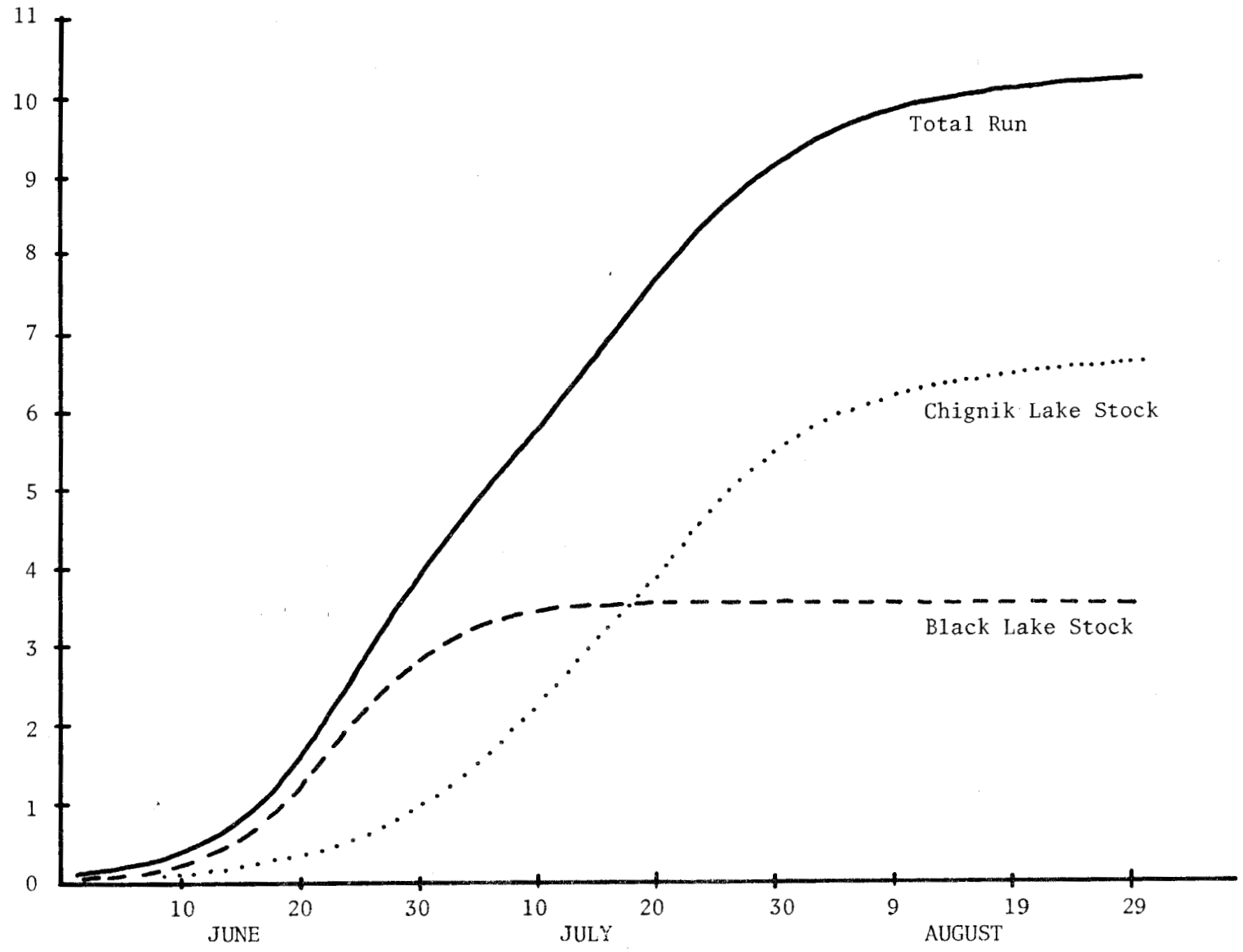


Figure 1. Expected time of entry of the Chignik sockeye run, 1969.

would allow an estimated harvest, after July 1, of approximately 400,000 sockeye.

Analysis of tagging studies conducted in 1963 and 1967 indicated that the Cape Kumlik fishery annually takes an appreciable number of the fish bound for Chignik; this catch is considered a part of the total catch of Chignik sockeye.

The anticipated 1969 total return and commercial harvest are summarized below:

	Predicted Total Return	Escapement Goal	Estimated Commercial Harvest
Black Lake	357,000	300,000-350,000	0-50,000
Chignik Lake	663,000	200,000-250,000	400,000-450,000
Total Chignik System	1,020,000	500,000-600,000	400,000-500,000

LITERATURE CITED

Dahlberg, M. L. 1967. Regression analysis in double precision. Univ. Washington, Fish. Res. Inst. Computer Prog. FRD 309. 4 p.

Dahlberg, M. L. 1968. Analysis of the dynamics of sockeye salmon returns to Chignik, Alaska. Ph.D. Thesis. Univ. Washington, Seattle. 337 p.

Narver, D. W. 1966. Pelogical ecology and carrying capicity of sockeye salmon in the Chignik Lakes, Alaska. Ph.D. Thesis. Univ. Washington. 348 p.

APPENDIX

Forecast Methods

Black Lake

Model used:

$$R_{.3} = \beta_0 + \beta_1 S + \beta_2 R_{.2} + \beta_3 SR_{.2} + \beta_4 S^2 + \beta_5 R^2_{.2} + \varepsilon$$

where $R_{.3}$ = Total number of age .3 fish in year i in 10,000's.

S = Total number of spawners in year i-5 in 10,000's.

$R_{.2}$ = Total number of age .2 fish in year i-1 in 10,000's.

ε = Experimental error.

The model was fitted to the data shown in Appendix Table 1 with the aid of a computer program written by Dahlberg (1967). Appendix Table 2 shows the analysis of variance test of the significance of regression. Appendix Table 3 presents the estimates of the coefficients of regression and the standard error of $R_{.3}$ on S and $R_{.2}$.

Appendix Table 1. Observed information used in forecasting the Black Lake run in 1969

Year (i)	Number of age .2 fish in year i-1	Number of age .3 fish in year i	Number of spawners in year i-5
1954	26,415	229,798	213,269
1955	18,607	376,502	206,270
1956	59,442	525,234	125,126
1957	8,442	262,588	34,155
1958	4,447	236,280	168,375
1959	24,316	233,671	184,953
1960	41,274	505,116	256,757
1961	19,984	171,271	289,096
1962	21,578	207,980	192,479
1963	29,653	295,608	120,862
1964	116,672	199,336	112,226
1965	66,142	736,505	251,567
1966	46,586	445,340	140,714
1967	11,722	316,629	167,602
1968	42,757	562,445	332,536
1969	22,212	--	137,073

Appendix Table 2. Results of analysis of variance of $R_{.3}$ regressed on the abundance of parent spawners and $R_{.2}$ fish, Black Lake

Source of variation	Sum of squares	Degrees of freedom	Mean square	F
Regression	3148.9890	5	629.7978	7.94**
Residual	714.2327	9	79.3592	
Total	3863.2217	14		

** Significant at p = 0.01.

Appendix Table 3. Least squares estimates of the parameters of the Black Lake forecast model, 1969

$\hat{\beta}_0$	$\hat{\beta}_1$	$\hat{\beta}_2$	$\hat{\beta}_3$	$\hat{\beta}_4$	$\hat{\beta}_5$	Residual Variance	Residual Standard deviation	Correlation coefficient
30.105	-0.410	-1.262	0.651	-0.038	-0.508	79.359	8.908	0.903

Chignik Lake

Dahlberg (1968) demonstrated the significant relationship between $R_{.3}$ and $R_{.2}$ with the following regression model:

$$\text{Log}_{10}\left(R_{.3} / R_{.2}\right) = a + \beta R_{.2} + \varepsilon$$

where:

$R_{.3}$ = Total number of age .3 fish in year i in 10,000's.

$R_{.2}$ = Total number of age .2 fish in year i-1 in 10,000's.

ε = Experimental error.

The model was fitted to the data shown in Appendix Table 4 and Appendix Fig. 1 by the method of least squares. Appendix Table 5 presents the analysis of variance test of the significance of regression. Estimates of the parameters are:

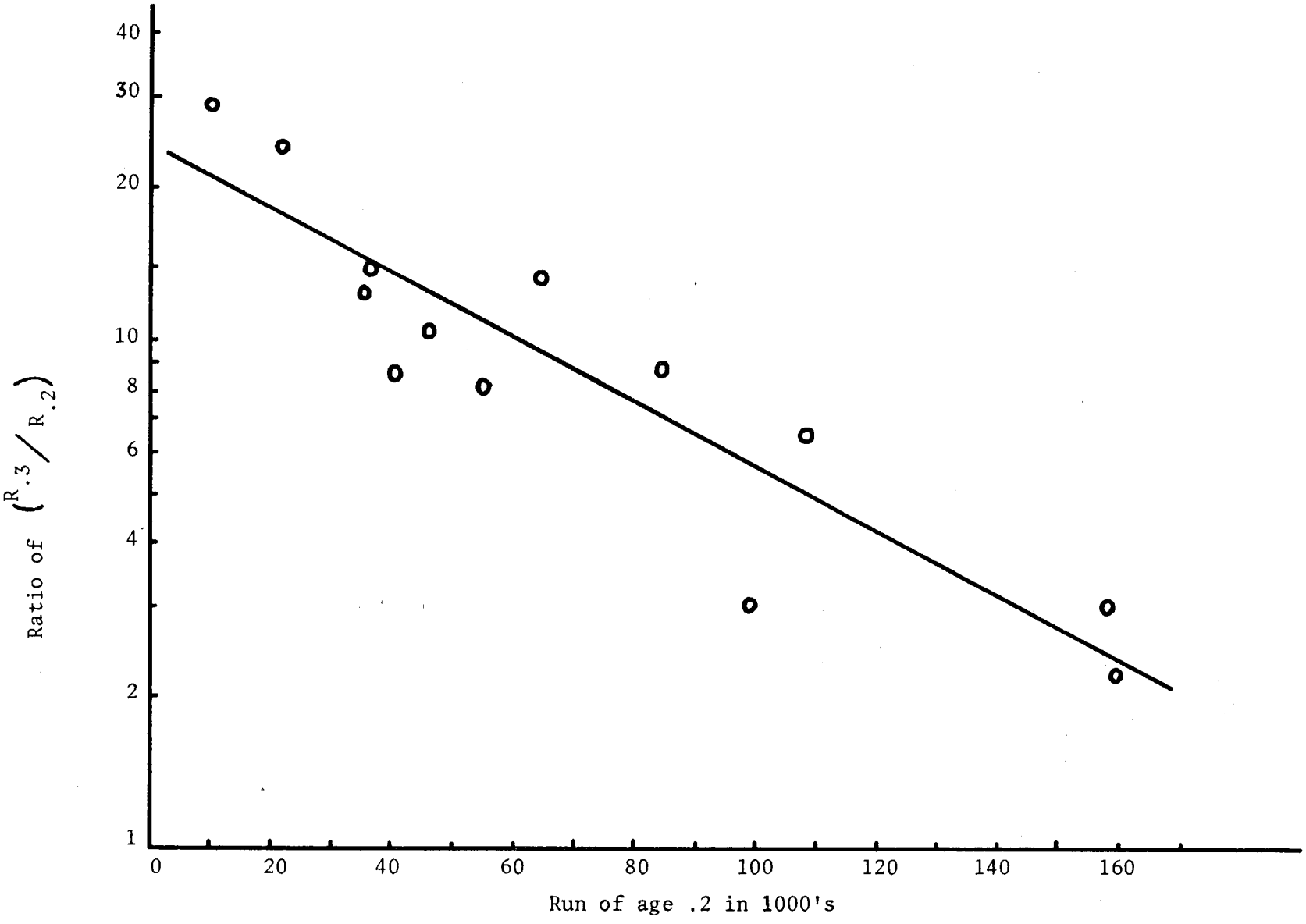
$\hat{a} = 1.38052$

$\hat{\beta} = 0.06223$

The estimated standard deviation of the line was 0.147.

Appendix Table 4. Observed information used in forecasting the Chignik Lake run in 1969.

Year (i)	Number of age .2 fish in year i-1	Number of age .3 fish in year i	Ratio of $R_{.3}/R_{.2}$
1956	64,493	865,205	13.415
1957	36,368	502,609	13.820
1958	40,003	354,962	8.873
1959	35,198	444,977	12.642
1960	109,483	727,854	6.648
1961	46,027	474,558	10.310
1962	55,111	453,562	8.230
1963	160,105	360,646	2.252
1964	159,995	492,523	3.078
1965	99,600	304,247	3.055
1966	10,351	302,885	29.261
1967	21,848	528,242	24.178
1968	84,384	765,777	9.075
1969	58,506	---	---



Appendix Figure 1. Relationship between the ratio of the return of age .3 fish in year i+1 to that of age .2 fish in year i and the abundance of age .2 in year i, Chignik Lake.

Appendix Table 5. Results of analysis of variance of $\text{Log}_{10}\left(R_{.3}/R_{.2}\right)$ on the abundance of $R_{.2}$ fish, Chignik Lake.

Source of variation	Sum of squares	Degrees of freedom	Mean square	F
Regression	1.11510	1	1.11510	51.927**
Residual	0.23622	11	0.021474	
Total	1.35132	12		

** Significant at p = 0.01.